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A Multidimensional Imaging Software Infrastructure

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Recent developments in microscopy have allowed extra dimensions of data to be extracted and recorded from a specimen over and above the two dimensions of a simple image. Techniques for optical sectioning have been developed that can provide three-dimensional data from living specimens. The optical sectioning technique of multiphoton fluorescence excitation imaging can give lower levels of photoxicity and can obtain images considerably deeper into a specimen than the other commonly used fluorescence optical sectioning method, confocal imaging. Microscopy techniques capable of extracting even higher dimensions of data are currently being developed. Every individual volume element of an image (voxel) can have a color, represented as a multichannel spectrum. In the case of fluorescence microscopy, every spectral channel can also have an array of time elements representing a histogram of the excited state lifetime of the fluorescence signal at that wavelength leading to a total of six dimensions. The extra dimensions of spectra and lifetime can provide valuable information on the identities and relative abundance of combinations of fluorescent probes being detected and also on the physiological state of the cells being observed. The visualization of image data of greater than two dimensions is a challenge that must be met by programs that provide more sophisticated capabilities than just simple image viewing. Currently, multidimensional image data obtained from living specimens – produced by fast-improving optical microscopy techniques – lacks any computational infrastructure for comparative analysis of multiple archived sets or for visualization of these datasets. We are developing such an infrastructure to explore and analyze multidimensional biological image data online. Such an infrastructure will allow for open scientific research and scientific data integration by increasing accessibility to these massive data recordings. As initial efforts in this infrastructure, we have designed a novel multidimensional image compression system that uses wavelets, and an advanced biological visualization tool designed to allow easy visualization and analysis of multidimensional data.

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